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Cognitive psychology and design paradigms in the development of multimedia courseware

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Cognitive Psychology and Design Paradigms
in the
Development of Multimedia Courseware

by

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13. ABSTRACT *(maximum 200 words)*

Multimedia courseware has the promise of becoming a staple of instructional technology, but it must be built around sound design theories in order to be effective. The design of multimedia courseware should be based on instructional design theory, human factors, and cognitive learning theories. If these elements are not included in a deliberate manner, the multimedia courseware will not be an effective instructional tool.

This thesis explores relevant cognitive learning theories and design paradigms for multimedia courseware. It includes examples from a prototype system designed to train naval officers who must witness a pre-firing inspection of the 76mm/62 caliber gun mount.

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ABSTRACT

Multimedia courseware has the promise of becoming a staple of instructional technology, but it must be built around sound design theories in order to be effective. The design of multimedia courseware should be based on instructional design theory, human factors, and cognitive learning theories. If these elements are not included in a deliberate manner, the multimedia courseware will not be an effective instructional tool.

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I. INTRODUCTION

The development of interactive learning system (ILS) environments is gaining importance in military education and training. The learning systems are said to generate cost savings and increase the quality and objectivity of instruction (Götz, 1991, pp. 9-10). As the use of computers to enhance traditional methods of teaching and training increases, so will the use of multimedia and hypermedia tools. Designers of interactive learning systems must take into account the appropriate cognitive learning theories and design paradigms prior to designing their systems, so that the learning systems will have instructional effectiveness.

A. PROBLEM STATEMENT

The designer of any course of instruction must engineer the substance and sequence of the course, so that the student will absorb the stimulus material and demonstrate newly acquired knowledge. As learning, perception, and thinking are cognitive processes the designers of interactive learning systems must consider the connection between cognition and the ability of an instructional tool to satisfy instructional objectives.

Multimedia has the promise of becoming a staple of instructional technology, but its effective deployment is threatened by "hype." Many authors of articles in computer journals and periodicals concentrate on technology, ignoring the design factors required to make ILS effective teaching tools. The instructional

effectiveness of its components must be analyzed before this new technology is integrated. Courseware designers must be sure the system provides the instructional benefits they envision.

> ... computers and computer-controlled devices offer great promise for revolutionizing education. It is also a commonplace (sic) that education is in need of revolutionizing. In the United States, the land of the technological fix, optimists might hope that this situation neatly matches tool and task, with a guaranteed positive outcome. I share the vision, but not the optimism.
>
> Realizing the revolution will require solutions to many knotty problems. There are, of course, a host of technical problems to be overcome in hardware and software design. More challenging, at least to me, are the pedagogical issues raised by the power of computer-based educational technologies: what should be taught, in what order, with what overarching conceptual structures and representations, by what mix of media, in what modes of interaction, and with what roles for student, software, ancillary materials, and teacher? At the root of these pedagogical issues lie even more fundamental questions, questions about how people think, communicate, and learn, questions about the mental processes and data structures we so often take for granted but about which we know so little. (Brackett, 1992, p.187)

The design of an interactive learning system should based on instructional design theory, human factors, and cognitive learning theories. If these elements are not included in a deliberate fashion, the interactive learning system will be less effective, because it is based solely on technology and disregards instructional effectiveness.

The purpose of this thesis is to emphasize the development of techniques, methods, and paradigms within the related technologies of computer-aided instruction, computer-assisted education, interactive multimedia, interactive learning systems, interactive video instruction, and multimedia courseware that enhance learning.

The critical research question that must be addressed by the designer of interactive learning systems for the military is: What interactive learning system design paradigms are best suited for military education and training requirements?

B. SCOPE OF THESIS

This thesis will explore relevant cognitive learning theories and paradigms used in the design of interactive learning systems and will outline a prototype system aimed at showing its applicability to military education and training. This paper is intended to provide concrete methodologies for the development of multimedia courseware. We will not, however, debate the need for or cost effectiveness of multimedia courseware.

This research project is the initial component of a larger project intended to lay the foundation for future study and development of interactive multimedia courses of instruction.

C. METHODOLOGY

The project was a joint effort of two thesis groups. The first group addressed the research question: "How do the various media effect the perceptual and cognitive aspects of learning and retention?" by conducting an in-depth study of media selection models (Benjamin & Spondre 1993). The second (our thesis), began with an in-depth exploration of cognitive learning theories and design paradigms used in developing interactive learning systems. The next phase of the project was to design a model interactive learning system. After becoming familiar with the UNIX operating system, Open Windows (Sun Microsystems, Inc., 1990), FrameMaker (Frame Technology Corp., 1990) and the MAEstro authoring system (Drapeau & Greenfield, 1992), we began the development of a prototype interactive learning system. To date the prototype has a partially developed concept map and fifteen screens. No video or audio segments have been included thus far.

D. LIMITATIONS

The initial prototype was designed for a UNIX environment using UNIX based and compatible authoring tools and multimedia hardware. This was the initial phase of developing multimedia courseware at the Naval Postgraduate School. As such:

(1) The project required the purchase of individual peripheral devices to create the interactive multimedia system. Not all devices were available for the project to be completed on time; and

(2) The authoring system, MAEstro, was still under development and did not fully meet our needs because it does not support interactive hypermedia document development. FrameMaker was used to simulate an interactive hypermedia environment.

E. ORGANIZATION OF PAPER

Chapter two examines the cognitive processes involved in learning, memory, and knowledge organization. Chapter three discusses various instructional design theories, instructional techniques, courseware design paradigms, and a notional interactive learning system model. In chapter four, we will present a series of design guidelines that we compiled from the review of literature. We will also discuss the screen designs of the prototype multimedia courseware. Chapter five is a brief listing and description of the hardware and software used in the initial development efforts. Chapter six presents conclusions and recommendations for possible future development.

II. COGNITIVE LEARNING THEORY AND MULTIMEDIA COURSEWARE

Cognition refers to conscious mental processes - perceiving, remembering, appraising, imagining, reasoning, and thinking (Kristal, 1982, p. 55). Thus, learning and knowing is the end result of a cognitive as opposed to a behavioral or emotional process. As an educational tool the central purpose of multimedia courseware is to enhance learning. The designer of multimedia courseware should therefore look for techniques that can influence the cognitive processes that facilitate learning. Effective interactive learning systems (ILS) or multimedia courseware must be based on cognitive learning theory and the basic tenets of instructional design, if they are to realize their potential as instructional tools. This chapter addresses the cognitive processes of perception, attention, and learning. We will also discuss memory systems, the factors that influence the encoding of information into memory, knowledge organization, and apprenticeship as they relate to the design of multimedia courseware.

A. PERCEPTION

Perception is the process of extracting information from the environment. "It is a higher level process by which the brain makes sense of sensations as well as receiving them" (Kristal, 1982, p. 178). Perception allows us to receive and process information about the environment and is therefore a more complicated process than simple sensations registered by sensory organs (eyes, ears, nose,

mouth or skin). As such, perception is the central cognitive process that enables learning.

> Learning is the process by which information is acquired through experience and becomes part of our repository of declarative knowledge. Thus, the results of learning facilitate further extraction of information..., i.e., perception (Forgus, 1966, p. 2).

"Learning is limited by what the learner perceives, and that can be influenced by the designer" (Fleming, 1987, p. 237). Consequently, the design paradigm of any ILS must facilitate the use of media that enhance perception by the learner. A critical research question that must be addressed by the designer is: What media is best suited for the perception of various types of information?

B. ATTENTION

Attention is defined as a selective narrowing or focusing of consciousness and receptivity (Merriam-Webster Inc., 1993, p. 114). The designer of an ILS must obtain and maintain the learner's attention. Without attention there can be no learning. "Influence on attention comes from both the display and the learner, and the designer has some control of both" (Fleming, 1987, p. 236). The designer must continually monitor the parallel processes of gaining and holding attention, because it is a resource with a limited capacity that can be allocated to only a few processes at one time (Taylor, 1992, p. 3). Taylor suggests that the novelty of multimedia contributes to its suitability for gaining, holding and directing user attention. He also emphasized the negative or counterproductive effect (loss of attention) that can result from the undisciplined use of multimedia.

Taylor suggests the following strategies for holding and directing learner attention: First, the use of **advance organizers or presentation of learning objectives** prior to instruction in order to prepare the learner for the lesson. Video segments are not suited for presenting detailed information, but they are an ideal medium for use as advance organizers or lesson summaries (Taylor, 1992, p. 3). Advance organizers provide a framework for the lesson as a whole by providing the student with an idea of where he or she is going. Advance organizers will be discussed in greater detail in the section on hypertext documents. Next, by using **multiple media**, the designer holds learner attention by providing variety during the presentation. Finally, **high-attention devices**, such as animation drawn in 24-bit color, or full motion video can be used to direct learner attention to important superordinate concepts (Taylor, 1992, p. 3-6). Figure 1 summarizes Taylor's ranking of attention getting/holding devices from greatest to least.

1. Sound + Movement (Moving Images)
2. Sound alone
3. Animated visual/graphic (silent)
4. Static visual/graphic (varying color and size)
5. Text only

Figure 1. Attention getting/holding devices from greatest to least (Taylor 1992, p. 3).

Figure 2 lists some potentially distracting features of multimedia. Multimedia courseware with these characteristics will not hold attention and thus not facilitate learning.

- Unsynchronized sound and movement
- Incomprehensible static or moving visual
- Repetitive sound, image, etc.
- Obnoxious Sounds

Figure 2. Features that can have a negative impact on attention (Taylor 1992, p. 3)

C. MEMORY SYSTEMS

1. Short-term Memory

Short-term memory (STM) is commonly regarded as the primary memory storage area akin to Random Access Memory (RAM) in a computer. Short-term memory serves as a buffer for data extracted from the environment by the senses. STM has limited capacity with respect to storage space (5-7 items) and duration (20 seconds or less) (Gagné & Glaser, 1987, p. 54, Salisbury, 1990, p. 26). The dominant mode of storage in STM is auditory. Consequently, the retrieval of a list of items from STM is similar to hearing each item. A visuo-spatial imagery system for short-term recall also exists (Gagné & Glaser, 1987, p. 54,

Kristal, 1982, p. 146). The term visuo-spatial refers to the "minds eye", i.e., being able to see a list of words in your head.

The relative capacity of short-term memory can be increased by a process called **chunking**. Chunking occurs when meaningful combinations or groupings are used to extend recall capacity (Gagné & Glaser, 1987, p. 54). For example, the terms IRS, EPA, NASA, USN, USMC, DoD, FBI, CIA) could be thought of as a collection of government agencies. In a comparison of experts to novices (Glaser & Bassok, 1989, p. 635) noted that

> ...experts and novices may be equally competent at recalling specific items of information, but experts chunk these items in memory in cause and effect sequences that relate to the goals and subgoals of problem solution and use this information for further action.

This statement implies that the chunking concept also applies to long-term memory (LTM).

An understanding of short-term memory is vital to designers and presenters. If new information is presented in a volume or at a rate that exceeds the learner's capacity to assimilate or process that information will be lost.

2. Long-term Memory

Long-term memory is basically a network of concepts and facts combined with numerous links or associations between them. LTM is a collection of organized knowledge, rules, procedures and episodes. It is separated into two types of declarative memory material **episodic and semantic**. Episodic memory is a record of personally experienced events separated by time and space.

Semantic memory is a data base of facts and files coupled with the ability to cross reference that information (Gagné & Glaser, 1987, p. 56, Kristal, 1982, p. 147). Both episodic and semantic memory are declarative (factual). Episodic memory is considered to be autobiographical and semantic memory contains general knowledge (Squire, et al., 1993, p. 457). Semantic memory is further divided into **declarative knowledge** ("knowing what") and **procedural knowledge** ("knowing how") (Gagné & Glaser, 1987, p. 60, Stillings et al., 1987, pp. 18-19). Procedural knowledge can be described as a compilation of rules, heuristics and procedures for association of old knowledge and compilation of new knowledge.

In subsequent discussions on instructional design, we will demonstrate the practical implications of selecting design paradigms that facilitate efficient encoding of information into LTM.

3. Working Memory

Although working memory is associated with STM, it differs in that the data is not just routed but actually processed. Like STM, working memory has limited capacity. Information is processed for future use in working memory by comparison or "matching" of new information with information previously stored in long-term memory. Information retrieved from LTM is "matched" for recognition and later combined or integrated with old information (schema -organized knowledge) and is then moved to long-term memory for storage (Gagné & Glaser, 1987, p. 55). <u>Comprehension occurs in Working Memory</u>. Practice and rehearsal can reduce the demands on working memory by increasing the speed at which

declarative knowledge, procedural knowledge, and episodes are recalled into working memory (Gagné & Glaser, 1987, p. 63). The concept of automaticity - the speedy recall of declarative knowledge will be discussed in a subsequent section.

D. KNOWLEDGE ORGANIZATION

Once information has entered long-term memory it is said to have been learned (Gagné & Glaser, 1987, p. 63). But, information in LTM is not a free floating entity. Information is organized in memory as a set of relationships, concepts and patterns called **schema**. Schemata are "organizers of patterns" or "a modifiable information structure that represents generic concepts stored in memory" (Gagné & Glaser, 1987, p. 69). Schema contain everything that we understand about a concept, including rules, procedures, interrelationships between objects and expected sequences of events. "It is the organization and structure provided by schemata which allow relevant knowledge to be found in memory." (Gagné & Glaser, 1987, p. 70) Therefore, schema influence the encoding of new information and provide the framework in which old information is recalled into working memory.

Gagné suggests that instruction must be designed for initial encoding and LTM storage.

> The objective of a drill should not be just to "burn it into memory" but to help learners to convert a learning task which does not have much inherent meaning into something more meaningful. (Salisbury, 1990, p. 27.)

Salisbury recommends designers help the learner add meaning to the material by utilizing mnemonic devices or mediators. For example, a mnemonic used to recall the internal combustion process in a four stroke diesel engine is (**SUCK, SQUEEZE, BANG, BLOW**). The mnemonic may seem crude but it is extremely effective because it **directly relates each word to a physical process**. The following example (which we both remembered) was presented to us at the Navy's Surface Warfare Officers School Command (SWOS) over seven years ago. The mnemonic is effective in complicated text or annotated graphics as in the following examples:

> The diesel engine combustion cycle consists of intake, compression, power and exhaust events for each power impulse. Four stroke cycle engines use four piston strokes and two revolutions of the crankshaft to accomplish these events.
>
> INTAKE STROKE - The piston descends and draws in fresh air through the open intake valve. **(SUCK)**
>
> COMPRESSION STROKE - After the piston passes bottom dead center the intake valve closes and the piston rises, compressing the air trapped in the cylinder. **(SQUEEZE)**
>
> POWER STROKE - Near top dead center, fuel is injected and ignites. Hot combustion gases drive the piston downward. **(BANG)**
>
> EXHAUST STROKE - As the power stroke ends the exhaust valves open, as the piston rises the exhaust gases are pushed out of the cylinder. **(BLOW)**
>
> When the piston reaches top dead center again the exhaust valves close and the intake valves open, thus the entire cycle starts over again. (SWOS 1987, p. 4-1)

Figure 3 is an adaptation a graphic (SWOS 1987, p. 5-1) annotated with the mnemonic memory aid.

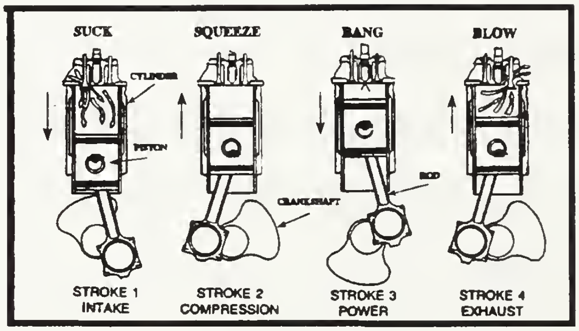

Figure 3. Mnemonic memory aid used to teach the four stroke diesel engine cycle. (SWOS 1987, p. 5-1)

E. MEMORY MODEL

Figure 4 is a model of the flow of information and the active cognitive processes that act on raw data to create knowledge. Attention and perception are required to extract data from the environment via our sensory organs. The storage space for newly acquired data is limited, therefore it must be processed so we can create new schema or associate it with pre-existing schema. Rehearsal and practice facilitate encoding of data by strengthening associations that allow faster or automatic recall of episodes, declarative, and procedural knowledge. Interactive learning systems should be designed with consideration for the flow of information in memory and the organization of knowledge.

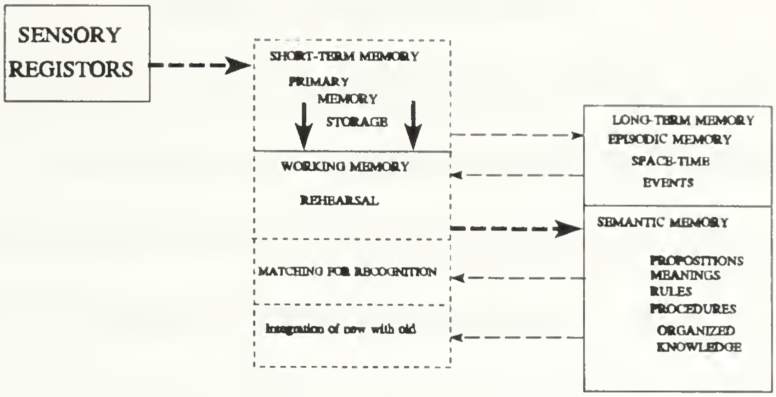

Figure 4. Information flow in the short- and long-term memory systems. (Gagné & Glaser, 1987, pg. 55)

F. AUTOMATICITY

Practice, drill and rehearsal aid in the transition of new information from short-term memory through working memory and ultimately to long-term memory. Practice and rehearsal are often discussed in regard to developing complex motor skills such as swinging a golf club or shooting a basketball. Practice enhances muscle memory and consequently reduces the amount of concentration required. In short, the athlete's actions become reflexive. **Reducing the amount of concentration or cognitive overhead is also crucial to learning complex cognitive skills**. The automaticity of subskills is vital, because of the limits in the capacity of working memory. The number and complexity of mental operations that can be carried out simultaneously is restricted (Salisbury, 1990, p. 23).

In a study on the acquisition of cognitive skills, Anderson (1987, pp. 194-206) noted that general domain knowledge (declarative knowledge) can be stored in

memory without effort, but considerable effort is required to recall and convert this knowledge into a format that can be used to solve problems. However, through a process called **knowledge compilation**, declarative knowledge becomes procedural. Procedural knowledge can be recalled and applied in working memory with less effort than declarative knowledge. Procedural knowledge is also strengthened and refined by repetitive use. Therefore, over a period of time and after repeated use, the procedures themselves become automatic.

In the cognitive domain there are many examples of subskills that become reflexive. Addition, subtraction, multiplication and division are examples of procedures that must become automated before a learner can tackle more complicated mathematical principles.

> In other words, if a student is required to concentrate a great deal of working memory on the performance of one of the subskills, performance on the higher level skill will be attenuated. (Salisbury, 1990, p. 23)

Interactive learning systems should include facilities for practice and evaluating performance of basic subskills as well as higher skills by learners. Subskill performance evaluation is most important in systems used for training. Salisbury recommends the following advice on developing automaticity of subskills in drill and practice programs:

(1) In addition to accuracy, speed and the ability to perform the skill without interfering with a secondary task should be used as criteria for mastery;

(2) Provide practice in basic subskills before moving on to more complex skills; and

(3) Evaluate and remediate performance in skills in terms of bugs in subskill performance.

G. INTERFERENCE

Learning can be adversely affected by conflicts between old and new information. Interference causes difficulty in learning a set of items as more items are introduced. **Retroactive interference** occurs when new information interferes with the recall of old information. **Proactive interference** occurs when old information prevents the recall of new information (Salisbury, 1990, p.24). Language studies provide good examples of proactive interference. For example, a student who has previously studied French in high school at times finds it difficult to learn similar Spanish vocabulary words in college. An example of retroactive interference would be learning the new capabilities of a modified system and being unable to recall capabilities of the original system. Salisbury (1990, p. 28) offers the following advice for reducing interference:

(1) Have a student drill on only a small subset of items at a time (Spaced Practice);

(2) Provide review of old items as new items are introduced (Spaced Review); and

(3) Emphasize the differences among competing stimuli gradually diminishing those differences until stimuli resume their normal condition.

H. APPRENTICESHIP AND LEARNING

Reeves (1992, p. 51) promotes the use of Interactive Multimedia (IMM) as a means of providing **situated-learning** where knowledge is learned in a context of use. IMM could be used to simulate or approximate an actual environment in which a student can demonstrate a target skill.

> A major benefit of well-designed IMM is that it can include opportunities for simulated apprenticeships as well as a wealth of learning support activities such as modeling and coaching. (Reeves, 1992, p. 51)

A well known benefit of multimedia technology is the ability to incorporate testimony from experts using video segments. The expert or "journeyman" could be supported by simulations that allow the student or "apprentice" to practice the skills presented by the expert. Collins et al., (1989, p. 453) developed the term "**Cognitive Apprenticeship**." They explore the use of apprenticeship-like teaching methods (*observation, coaching, and successive approximation*) for teaching cognitive skills; specifically, reading, writing, and mathematics. Because apprenticeship is a staple teaching method used in the military, the formulation of simulated or cognitive apprenticeships through IMM would be well suited for a majority of military training applications. The student could use or relate the simulations to personal experiences or episodes. Referring back to Figure 4, events or episodes are encoded directly into LTM.

Collins et al., (1989, p. 456) outline the processes of observation, modeling, scaffolding, fading, and practice or successive approximation. In apprenticeship, the learner observes the expert performing a target skill. That image forms the

model of the ideal performance for the student (modeling). The student then attempts to recreate the actions of the expert through successive approximation or practice. The expert (or **learning system**) then coaches the student by providing scaffolding - support in the form of reminders to guide the student through more practice. As the student becomes proficient at the skill the system or coach begins to fade providing progressively fewer hints and refinements.

A notional ILS should attempt to form "cognitive" or simulated apprenticeships where possible. The use of video segments can provide the learner access to a larger body of experts than are normally available in a classroom setting. The degree of similarity to a real apprenticeship would be determined by the quality of the simulation or practice facilities.

The designer must have the appropriate level of interactivity and feedback built into the system for an apprenticeship model to work.

I. SUMMARY

The cognitive processes that facilitate learning can be influenced by the design of the course of instruction. The courseware designer must engineer the substance and sequence of the course, so that the student will absorb the stimulus material and demonstrate newly acquired skills. By enhancing perception, maintaining learner attention, providing additional meaning to stimulus material, and reducing interference the designer can accomplish his or her instructional objective.

III. MULTIMEDIA COURSEWARE DESIGN

Multimedia courseware is intended to teach, educate, or train learners. Therefore, it must apply instructional design theories and employ various instructional techniques in the same way an instructor would apply them. By using its unique features multimedia courseware can deliver stimulus material and evaluate learner performance. This chapter will be dedicated to the discussion of instructional design theory, instructional techniques, multimedia courseware design paradigms, and interactive learning system models that can be used in the development of multimedia courseware.

A. INSTRUCTIONAL DESIGN THEORY

1. Learning Style and Learner Characteristics

A common axiom about the design of instructional material is that educators must accommodate various learning styles when designing material for general use. Conversely, research conducted by NCR Corporation suggests that the effectiveness of Interactive Video Instruction (IVI) is independent of the student's learning style - the characteristic way an individual generally chooses to perceive and process new information (Larsen, 1992, p. 17). Larsen's explanation of why IVI can accommodate varied learning styles is that (dependent on the degree of learner-control provided by the system) the inherent nature of IVI allows for user control of content, pace, direction and learning strategy. The user can

choose to review, attend to details or generalize, pause and ponder, or forge ahead in an trial-and-error fashion (Larsen, 1992, p. 18). An ILS that provides a mechanism for learner-control should be effective regardless of learner style.

Because learning style does not affect the effectiveness of a learner-controlled ILS, the designer must give greater consideration to the characteristics of an individual learner. The learner's **reading ability and age are significant factors** to consider when designing interactive courseware. Some researchers propose that pictures and spoken words help facilitate learning by less accomplished readers. Other learning theorists note that older or more experienced learners require less guidance because they have better developed learning strategies. Designers of Interactive Multimedia Courseware are advised to use abstract media for older students and concrete media and experiences for younger users when attempting to relate "cognitive type" learning objectives. The presentation process should be reversed when conveying "material intended to formulate attitudes" - concrete media for older students and abstract media for younger less experienced learners. (Reiser & Gagné, 1983, p. 20)

The designers of multimedia courseware used by military personnel cannot simply assign demographic design criteria. Personnel between the ages 17 and 45 have a wide range of educational backgrounds, reading ability, experience and skill performance requirements. Careful **analysis of the learners** -the target population for the courseware must be conducted. You must obtain a

> ...clear definition of the target population - the group of people for whom the instruction is intended...and identify those characteristics of the target population which are likely to influence the design delivery, and utilization of instruction. (Kaufman & Thiagarajan, 1987, p. 135).

The course objectives, media choice and method of instruction are all dependent on learner characteristics. The target group for our prototype course would vary greatly in age, level of experience, and reading ability. The procedure card for conducting the pre-firing inspection was the basis for Appendix A. The actual procedure contains detailed illustrations and steps. Regardless of reading ability the complex and non-routine procedure may still remain unclear after initial readings. Personnel conducting complex procedures of this type are normally provided some amount of apprenticeship (dependant on prior experience).

2. Events of Instruction

Gagné and Reiser (1983, p. 41) and Reigeluth and Curtis (1987, p. 191) commenting on early work by Gagné, stated that there are nine relatively sequential **events of instruction** that will facilitate learning:

(1) gaining attention;

(2) informing the learner of the objective;

(3) stimulating recall of prerequisite learning;

(4) presenting the stimulus material;

(5) providing learning guidance;

(6) eliciting the performance;

(7) providing corrective feedback;

(8) assessing the performance; and

(9) enhancing retention and transfer.

Each of the events can be associated with the model of information flow through the short-term and long-term memory systems, the cognitive processes of attention and perception, automaticity, and knowledge organization. Examples of the various events are (1) varying media, using closeups, or highlighted text; (2) statement of learning objectives and use of advance organizers (video segments are an ideal medium for this purpose); (3) recall of prior knowledge to working memory (can speedup recall by rehearsal and practice); (4) presenting information in the proper sequence using media that is best suited for stimulating learning (visual, audio, real object, etc.); (5) providing context to associate new information to larger schema or propositions; (6) questioning the student on the main points or requiring the student to summarize the lesson; (7) providing the student with a timely response about the correctness of their answers and clarifying misconceptions (hallmark of interactive systems); (8) testing or requiring the student to restate information in their own words; and (9) providing additional examples or using mnemonics.

3. Task Analysis

"Job and Task" analysis studies should be conducted when teaching complex tasks or skills. The analysis will provide the designer with a clear idea of which steps are important in a task and in what sequence to teach them , and the relationships between each step and the task as a whole. (Merrill, 1987, p. 141)

Critical task analysis is a crucial step in the design of systems that will be used to teach or train students how to perform a task. Merrill provides detailed procedures for conducting job or task analysis. Merrill (1987, p. 149) also provides an alternative approach to task analysis called an "information-processing approach". This approach includes the following steps:

(1) Identify the operation and decision steps of the procedure.

(2) Sequence the steps in the order in which they would be performed.

(3) Prepare a flow-chart representation of the sequence steps.

(4) Validate the flow-chart, using several different initial inputs.

We began by outlining the maintenance procedure for conducting the pre-fire inspection on a MK 75 76mm gun (Appendix A). The overview of the procedure flows as outlined in Figure 5.

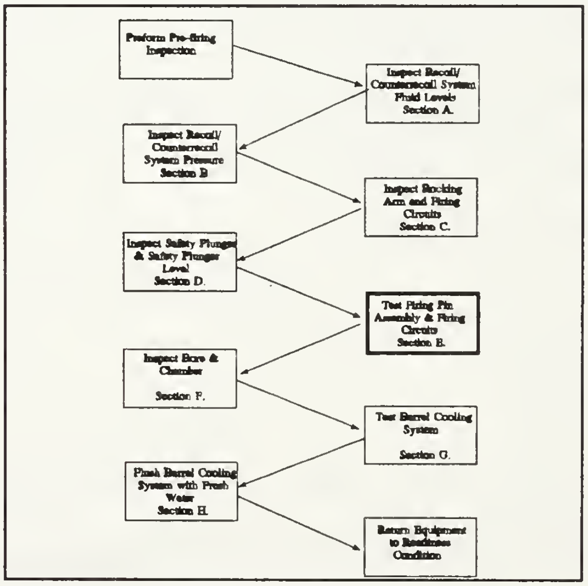

Figure 5. Sample task outline.

The highlighted box in Figure 5 is the focal point of the prototype courseware. The steps within that section of the procedure must be witnessed by the target group for our interactive multimedia lesson. Figure 6 is a further refinement of the task analysis process.

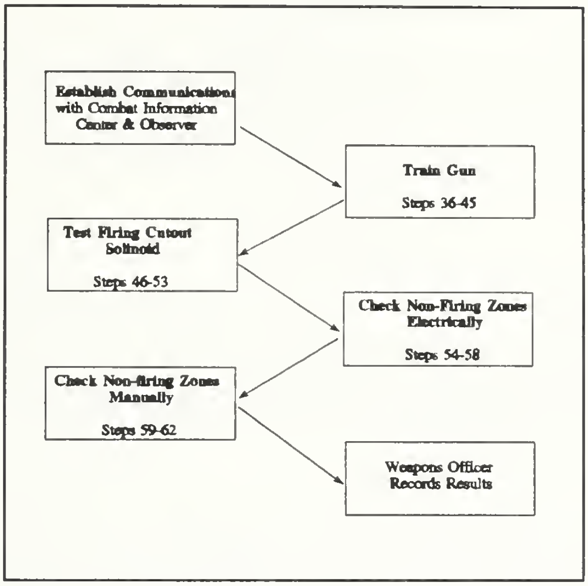

Figure 6. Detailed example of task analysis.

4. Learning Objectives

After identifying what is to be taught, the designer must arrange the material in a sequence that best supports learning. The common axiom of instructional sequence is a flow from general to specific. It is a continual process of refining or increasing the level of detail until the complete skill is learned. Reigeluth and Curtis (1987, p. 181) in discussing previous work by Gagné and Briggs suggest that the sequence of instruction should first establish "life-long" objectives, then "end-of-course" objectives, followed by "target objectives", "performance objectives", and finally "enabling objectives". This process is

congruent with cognitive learning theory that emphasizes the mastering of prerequisite skills first. Instruction must be designed so that the learner can comprehend the big picture (the whole) and subordinate concepts (the parts). Figure 6 outlines the sequence of instructional objectives.

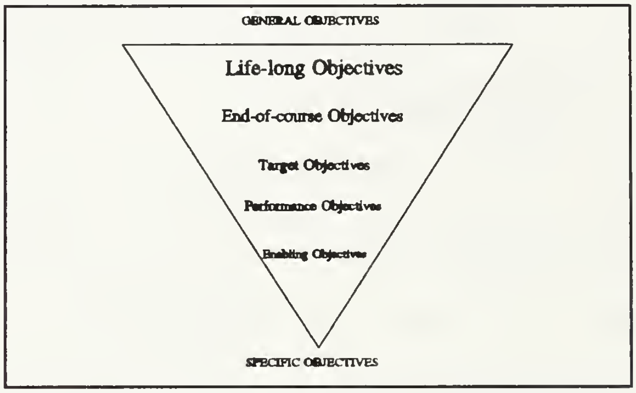

Figure 7. Sequence of Instruction and Presentation of Learning Objectives.

Course material and learning objectives should be presented in a sequence that moves from the presentation of general to more specific material.

B. INSTRUCTIONAL TECHNIQUES

1. Pace and Forced Pauses

Control of the pace of instruction is another aspect of the user control (internal) verses program control (external) paradigm. A study conducted by Milheim (1990, p. 15) indicates that long and short-term retention is increased in user paced applications. Kline (1992, p. 64) who recommends less than total user control reviewed different pacing strategies that could be used for textual and pictoral material. His study used the technique of removing text from the display

after a preset period and presenting pictoral displays five seconds before textual information to focus user attention on the pictoral display. Kline asserts that external pacing strategies do not hinder learning, if the student is given ample "cognitive processing time", i.e., enough time to view and think about material before proceeding to new items. Gillingham (1988, pp. 1-6) in a review of the issues surrounding text in computer-based instruction concentrated on pacing strategies such as the length, amount, and rate of text presentation. His analysis of textual pacing is congruent with Kline's research:

> ... Rate of (text) presentation has an effect on comprehension when a reader cannot control the text at the page (or screen) level....(Gillingham 1988, p. 2)

The use of forced pauses and guidance messages to enhance cognitive processing by students was tested in a series of experiments by Smith (1990, pp. 2-38). The study focused on the duration and placement of forced pauses that are intended to make the user consider or ponder the material that was just presented. Pauses were placed:

(1) After the presentation of objectives;

(2) After the presentation of stimulus material, but before the presentation of review questions and summaries; and

(3) After the section summaries.

Pause location was not found to have any statistical effect on test scores. Smith (1990, p. 9) suggested that pauses placed after summaries would be more efficient, because of shorter program completion time. With respect to **pause duration**; the research indicates that pauses between 20 and 40 seconds

did not interfere with learning and pauses of 40 seconds were superior to those of 20 seconds regardless of location. Pauses could be used to restore resources (rewind tape, etc.) and as an instructional feature, if placed at logical breaks in the presentation (Smith, 1990, p. 9).

The use of **guidance messages in a user-paced pause setting** yielded less general conclusions than the experiment on forced pauses. The use of self-paced pauses appearers to be less conducive to learning. Researchers noted that the length of self-paced pauses were significantly shorter than the forced pauses. Users even tended to immediately page forward when they saw the message "Consider the material presented so far" (Smith, 1990, p. 12). This type of automatic pressing of the "space bar" negates cognitive processing. The user does not think about and digest the material that was presented before proceeding with the lesson.

2. Spaced Practice

Salisbury (1990, p. 25) recommends providing a mechanism that keeps track of the student's place in the lesson, so the student may exit the program at will or at a logical break point. The student should be able to resume the program without having to start at the beginning of the lesson. In reviewing studies on spaced practice he found that;

> ...short, spaced periods of practice give better results than long concentrated practice periods...space practice is considered to be more effective than massed practice (because) the learning context on each occasion is somewhat different thus causing the information to be encoded somewhat differently each time....(Salisbury, 1990, p. 25.)

3. Spaced Review

Salisbury (1990, p. 26) also recommends using **increasing-ratio review** (i.e., gradually increasing the spacing between presentations of material). "Spaced review has been shown to be a significant means of enhancing retention of learned material." (Salisbury, 1990, p. 26) Spaced review simply means review items over a longer period of time. The designer should allow the student to review items from previous lessons or throughout the course of instruction.

C. DESIGN PARADIGMS

1. Internal vs External Control

One of the most talked about features of IMM is the ability of the designer to build in user control mechanisms (Cronin & Cronin, 1992, pp. 38-39, Barker, 1990, p. 134, Shaw, 1992, pp. 56-57, Milheim, 1990, pp. 8-10, Kline, 1992, p. 64). User control of applications used for training and education is said to provide additional motivation for the student and facilitates encoding of information into long-term memory. User control may provide a type of "individualized instruction" whereby the student can learn at his or her own pace and use their own learning style. Indeed, much of the literature suggests that some degree of learner (**internal**) control facilitates learning and retention.

> ...students should be made to feel that they are in control of what is happening during an interactive learning session.... Facilities must be provided to enable the student to select and control:
>
> - what is learned;
> - the pace of learning;

- the direction learning should take; and
- the styles and strategies of learning that are to be adopted.

(Barker, 1990, p. 134)

The literature clearly indicates the following: (1) user control is an ideal feature for courseware that is intended for use by adults and (2) user control is most effective when the learner has had some experience with the course material (Milheim, 1990, pp. 9-10, Shaw, 1992, pp. 56-57).

Shaw (1992, p. 56) states that the design of a tutoring system should accommodate different user modes: (1) Overview, (2) Sequential, (3) Discovery/Browsing, and (4) Look-up. However, the designer should realize that full interactivity implies an increased level of system complexity.

There is clearly a need for detailed evaluation of the instructional setting and the minimum training requirements - especially in a military setting because the degree of program control (external or internal) should be determined by the objectives of instruction. For example, there is a commonly held belief that there is a difference between training and education. Training is usually identified with the performance of a specific skill or set of skills, while education is intended to strengthen the repository of declarative and procedural knowledge and enhance the ability to compile new knowledge.

Thus, courseware that is primarily intended to train the user to perform specific procedures or demonstrate specific skills should have less internal (user) control than courseware designed to expose the learner to various issues in a given field of study.

Milheim (1990, p.9) suggests some alternatives to total user control or program control. (1) **Adaptive control** - using an algorithm to match the learning environment to student needs and characteristics. (2) **Advisement control** - learner makes some decisions regarding content, sequence etc. but the program makes suggestions for some choices.

2. Media Selection

Given what we have already discovered about attention, perception and learning, the designer must select media that enhances learning. Remember that without attention or perception of stimulus material there can be no learning. Multimedia technology allows the designer to incorporate the media of their choice.

Surveys and interviews conducted by a research group from the Navy Personnel Research and Development Center (NPRDC) of representative Navy training facilities indicate that;

> Media selection decisions are made on the basis of instructor/subject matter expert judgement, cost, availability of production equipment and manpower rather than a media selection model. There is no routine process for evaluating the instructional effectiveness of new or existing media.... Objective instructional effectiveness was not mentioned as a major consideration in media selection by any respondent. (Ulozas, 1992)

Benjamin and Spondre (1993) examine and compare various media selection models. As the media selection process is beyond the scope of our thesis, we will only provide a cursory examination of media selection theory.

According to Reiser & Gagné (1983 pp. 11-28) media selection models are based on the following factors:

(1) Instructional Setting;

(2) Learner Characteristics;

(3) Categories of Learning Outcomes (Learning Objectives);

(4) Events of Instruction;

(5) Physical Attributes; and

(6) Practical Factors.

These factors fall into three categories (1) physical attributes of media; (2) learner, setting, and task characteristics; and (3) practical factors. Practical factors include cost of production and production equipment availability.

3. Hypermedia

a. Definition

Begoray (1990, p. 122) noted that readers usually proceed in a linear fashion when reading fictional text and in a hierarchical form when reading technical prose using the table of contents, major headings and sub-headings, etc. In an hypermedia environment, the reader is able to proceed in a non-sequential manner. He or she is given the ability to navigate through the document or

(knowledge corpus) using various paths (Barker, 1990, p. 134, Begoray, 1990, p. 122, Benest, 1991, p. 341-343). For example, the reader can select an item in a list or sentence and view additional information relating to that item. Hypermedia involves the use of hypertext and multimedia (**Hypermedia = Hypertext + Multimedia**) (Kreitzberg, 1992, p. 16). It may include: text, animation, graphics, full-motion video or audio inputs in a individual document or series of linked documents. Hypermedia has the same navigation scheme as hypertext. The ability to allow the user to control their paths is a major distinction between traditional audio-visual systems and a hypermedia system (Hapeshi & Jones, 1992, p. 81). As we are only concerned with the structure of the "Hyper-document", we will use the terms hypertext and hypermedia synonymously.

b. Design

Hapeshi and Jones suggest that experience is more conducive to learning and that students learn by trying and failing. With an interactive multimedia system, the students can experiment and try out their ideas. Multimedia provides presentations that can present real situations.

The designer of an ILS must consider how much flexibility the user will be given in navigating the document. When using hypermedia, the designer must place the burden of structuring the text/media properly on the user. For this reason, while a writer moves linearly from beginning to end, a designer of hypermedia is discouraged from doing so. He or she should make discrete, relatively concrete points because the reader may not encounter important points

in the correct sequence. (Hapeshi & Jones, 1992, p. 86) Referring back to our earlier discussions on attention and the capacity of working memory, it should be clear that controlling the flexibility of hypertext is a crucial factor in ILS design.

> The hypertext learning environment, if it is to be viable, must not make intrusive demands upon the students attention. From the theory of limited attentional resources, it follows that if students are disoriented by a hypertext environment, mental resources which otherwise would be directed towards learning will not be available, because they will be directed towards orienting the student in the environment. (Tripp & Roby, 1990, pp. 120-121)

Hypermedia uses nodes and links to provide the user with the capability to "jump" through a system in a non-linear manner. The nodes are the basic unit of the system. They may include: text, graphics, video, animation or audio overlays. Nodes are connected by links. This may be accomplished through the use of a "button", text link or multimedia link (Kreitzberg, 1992, p. 18). The number of nodes in a document determines its **granularity**. Overly fine grained documents (too many nodes) are distracting. The user will become lost or disoriented by excessive paging between nodes. Unless it is necessary, there is no point in presenting huge chunks of information. Nodes should be short, meaningful units of one to several paragraphs in size (Begoray, 1990, p. 125).

The first step in creating a hypermedia system is defining a concise concept of what the system is designed to accomplish. From this, a storyboard is drawn up with specific topics graphically displayed. Relationships between the topics are indicated by lines between them. The "concept map" demonstrates the links between the various nodes of the hypermedia lesson (Kid et al., 1992, p.

145). Figure 8 is an example of a concept map. The content of an individual node will vary as will the media used within each node, i.e., text, pictoral, audio, video, mixed modal. The idea is to use the media best suited to convey the learning and teaching objectives. The level of detail in the concept map can be increased to show every node in the system. Some authors include the map in the system as a navigation tool allowing the user to have a graphic representation of the various pathways in the application.

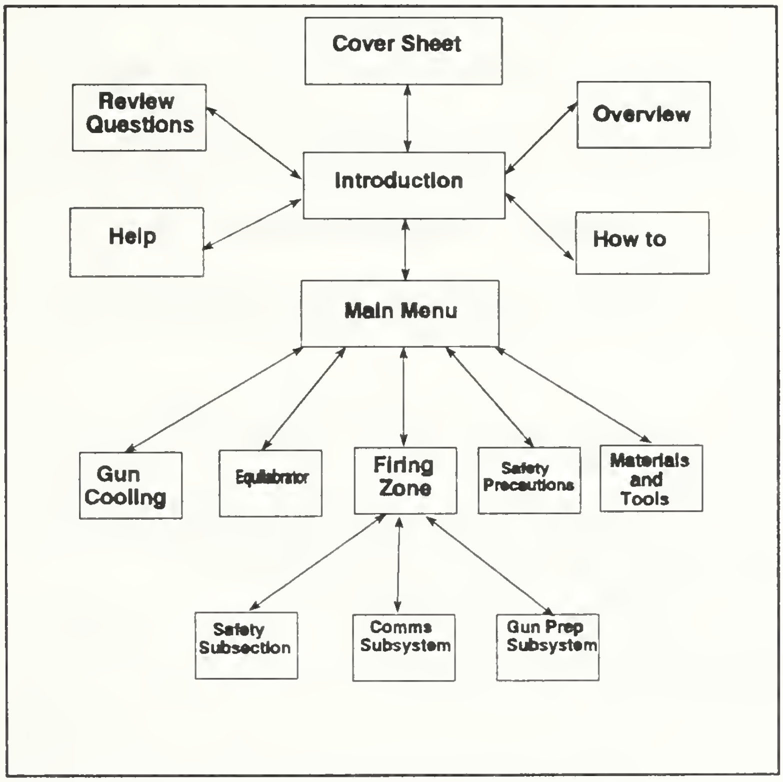

Figure 8. Concept Map for prototype IMM courseware.

Once the relationships are defined, the content of the nodes can be determined. This "concept map" is drawn and further refined to produce a detailed map of the intended system. (Kidd et al., 1992, p. 145)

c. *Navigating the Hyperdocument Environment*

Because the user has the capability to navigate through the system by creating their own paths, they may become lost or infer different meanings from the instruction than the designer intended. The hypermedia environment has a great deal of "**cognitive overhead**" (Benest, 1991, p. 342, Begoray, 1990, p. 128), therefore mechanisms to facilitate logical and unambiguous paths must be incorporated into the courseware. Hapeshi and Jones (1992, p. 86) suggest three methods for increasing a users understanding of the flow through the hypermedia system:

(1) The use of an "importance indicator" to show the use the best route;

(2) An "explain" option to assist when they have jumped to an argument without first encountering prerequisite arguments; and

(3) Important arguments can be presented in "linear" fashion to force the user through a set path.

Tripp and Roby (1990, p. 121) suggest using "advance organizers" to provide the user with meaningful information about the structure of database (knowledge corpus) or using verbal or visual metaphors (maps) that describe the conceptual organization of the knowledge corpus. In addition to the suggestions above, the designer may have tools built into their authoring system that keep track of the paths the user have created. For example, FrameMaker has the

capability of keeping track of the last twenty-four jumps. This allows the reader to click and trace their last twenty-four "jumps". FrameMaker also provides a function that allows graphical display of the current level within the hypermedia document. Figure 9 is an example of a screen with a level indicator. This graphic representation gives the user a feel for where they are.

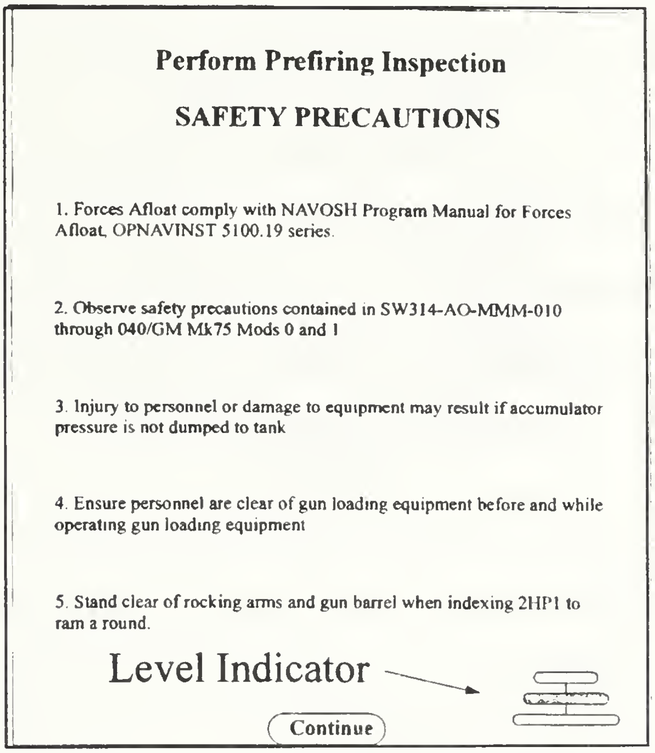

Figure 9. Sample screen with a graphical representation of node position.

D. INTERACTIVE LEARNING SYSTEM MODELS

Barker (1990, p. 127) established some guidelines for developing a notional Interactive Learning System (ILS) that can be used in an exploratory, informatory, or instructional mode. Baker's model - shown in Figure 10, demonstrates

interaction between the learner and the ILS through a number of sensory input channels. The ILS possess modelling capabilities and a primitive teaching system (PTS) on a layer of interfaces, paradigms, metaphors and myths.

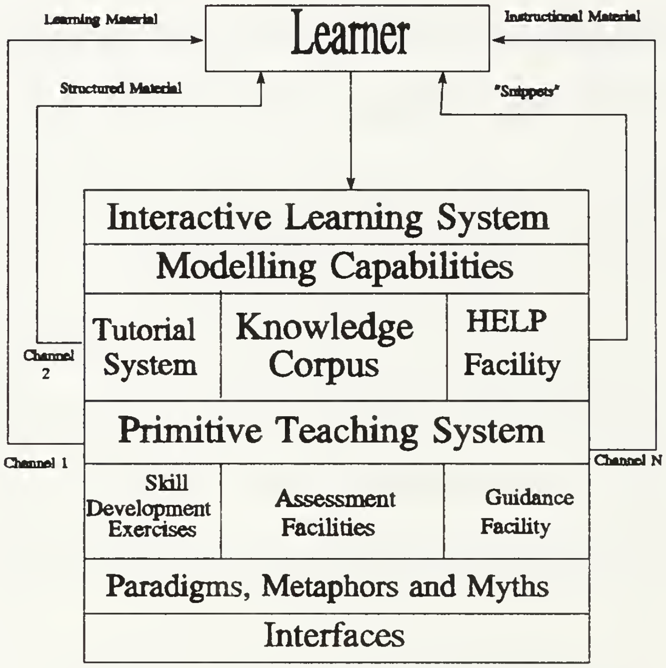

Figure 10. Basic design for a conventional ILS (Barker 1990, p. 131).

The modelling capabilities are designed to tailor instruction to the needs of the individual learners. The modelling module is comprised of (1) a tutorial system that provides structured material about the ILS and knowledge corpus (the tutorial system does not teach stimulus material); (2) The Knowledge corpus or database of domain knowledge (in multimedia format); and (3) Help Facility that provides pieces or 'snippets' of information about the system.

The Primitive Teaching System (PTS) consists of (1) Skill Development Exercises - questioning facilities, simulations, and practice facilities to help encode and associate information; (2) Assessment facilities to compare learner progress with the objectives of instruction and evaluate the need for more practice and feedback; and (3) a Guidance facility to reinforce objectives and steer the user through the knowledge corpus.

The layer of metaphors and myths are instructional design methodologies used to facilitate the transfer of knowledge (learning).

The final layer consists of the media utilization paradigms that comprise the environment within which the ILS will operate. Barker lists five media paradigms: **hypermedia, reactive media, surrogation, learner-control, and composite screen**.

Reactive media is the mode of human-computer interface (voice recognition, touch screen, mouse, key board, light pen, etc.) Surrogation refers to the capability for simulation and walk through in an environment of high resolution graphics or full-motion video. Learner-control refers to the degree of interactivity with and amount of control the user has over the application. (Refer to the section on internal verses external control.) Composite screen refers to the display format, i.e., multiple screens or various other display techniques.

In comparing our prototype to Barker's notional ILS, we fit the components of our prototype into Figure 11.

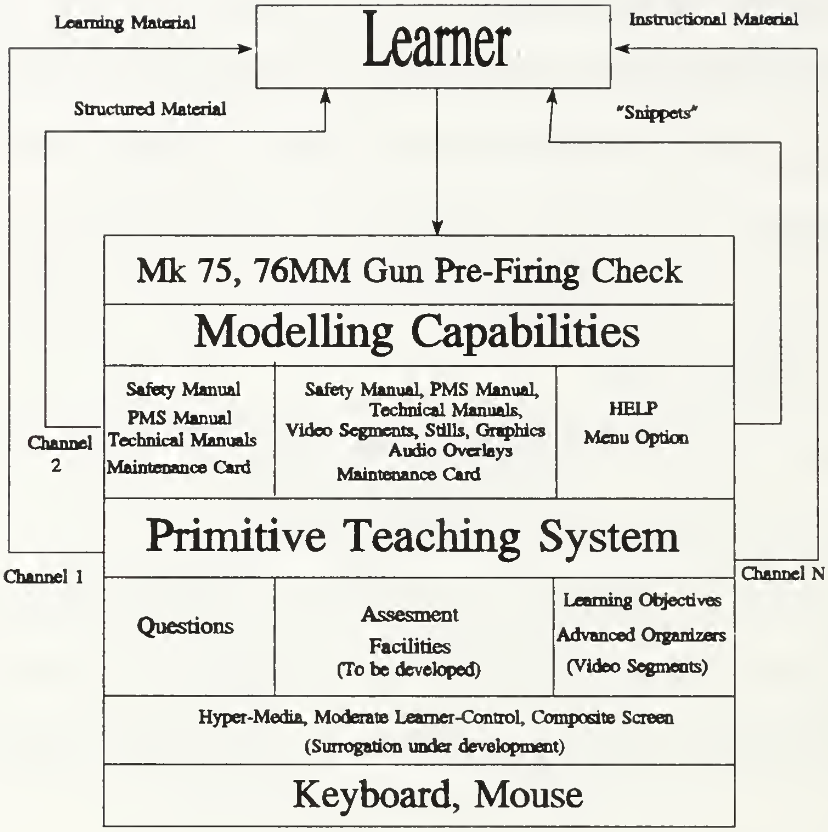

Figure 11. Prototype ILS underdevelopment at the Naval Postgraduate School.

IV. PROTOTYPE DEVELOPMENT

A. DESIGN GUIDELINES

There is no "cook book" for designing multimedia courseware. The design paradigms, instructional techniques, media choices, and instructional design methodologies employed will vary with the objectives of instruction. We have found the following works to be the best overall collections of "How to" knowledge available:

Chabay, Ruth W. and Sherwood, Bruce A. *A Practical Guide for the Creation of Educational Software.* In J. H. Larkin and R. W. Chabay (Eds.). *Computer-Assisted Instruction and Intelligent Tutoring Systems: Shared Goals and Complementary Approaches.* Hillside, NJ: Lawrence Erlbaum, 1992, pp. 151-186.

Fleming, M. L. *Displays and Communication.* In R. M. Gagné (Ed.). *Instructional Technology: Foundations.* Hillside, NJ: Lawrence Erlbaum, 1987, pp. 233-260.

Wetzel, C. Douglas et al., *Review of the Effectiveness of Video Media in Instruction.* NPRDC-TR-93-4, April 1993, Navy Personnel Research and Development Center, San Diego, CA, 92152-7250.

Reiser, Robert A. and Gagné, Robert M., *Selecting Media For Instruction*, Englewood Cliffs, NJ: Educational Technology Publications, 1983.

Inexperienced designers should review and become familiar with these works before attempting to develop multimedia courseware. Some of the guidelines from these works were incorporated in our prototype courseware and are listed in Appendix B. Some of the important guidelines are:

- Lean displays focus attention. Include only the most relevant information. (Fleming, 1987, p. 236)

- The designer who produces displays that are readily organized reduces the possibility that the learner will organize the material differently and perhaps erroneously. (Fleming, 1987, p. 238)

- Vision is most sensitive to colors in the middle of the spectrum, yellow and yellow-green, and least sensitive to those at the ends of the spectrum, violet/blue and red (Fleming, 1987, p. 239). Gillingham (1988, p. 2) noted that both reading speed and accuracy increase as the wavelength difference between foreground and back ground colors increases. Combinations leading to highest accuracy were blue or green on white, magenta on green or cyan, red on yellow or green, and white on black.

- Learners prefer color. Especially when it has relevance and meaning ("red bird" may be associated with cardinal). Color can direct attention. (ex. Highlighting words or sections of maps.) (Fleming, 1987, p. 244)

- Repetition increases learning. Repetition with variety is superior to verbatim repetition. (Fleming, 1987, p. 248)

- Mix text and pictures. Labels and captions clarify pictures and graphs. (Chabay & Sherwood, 1992, p. 157)

- Remove text and graphics from the screen when they are no longer needed. (Helps to focus user attention and reduces interference.) (Chabay & Sherwood, 1992, p. 161)

- Build up displays incrementally. Do not flood the screen with all the information at once. (Limited capacity of short-term memory and interference.) (Chabay & Sherwood, 1992, p. 161)

- Connect text with graphics. Graphics can shorten lengthy textual explanations. (Chabay & Sherwood, 1992, p. 163)

- Where possible provide a consistent location for displaying new information (a particular region of the screen). (Chabay & Sherwood, 1992, p. 164)

- Put instructions on the screen. (Chabay & Sherwood, 1992, p. 174)

- Always provide the user with a way out. (Chabay & Sherwood, 1992, p. 183)

- Provide the user with a sense of where they are in the lesson. (ex. "5 screens to go") (Chabay & Sherwood, 1992, pp. 183-184)

- Short lists are best presented in auditory form, longer ones in visual form. (Hapeshi & Jones, 1992, p. 96)

- Speech information should be used sparingly; expert summaries are better for learning than long passages, if the auditory channel is used. (Hapeshi & Jones, 1992, p. 96)

B. PROTOTYPE OVERVIEW

The screens shown in Appendix C were developed from the flow of our concept map. You will note that some of the screens have icons that indicate a linkage to a video clip. The icon  represents a node in the system. Text can be highlighted to indicate other links by using colors or unique fonts (Begoray, 1990 p. 126). Cues used to indicate the active areas or links should be consistent. In our on-line prototype we used **red** text, icons, and the phrase "select one" to indicate our jump points. The user would activate the links with a mouse. The screen layouts incorporate the design hints from Appendix B.

1. Advance Organizers and Learning Objectives

The video icon is displayed prominently at the beginning of the lesson. The icon would launch a video clip that provides and overview of the lesson in order to prepare the user for the up coming lesson.

The learning objectives are also displayed at the beginning of each lesson segment so that the user knows exactly what they are to learn.

By presenting the learning objectives or using the video clips (high-attention getting device) as a advance organizers the designer can focus or direct user attention.

2. Hypertext Active Areas

The tools, parts, and material screens in Appendix C demonstrate the use of text as jump points to other nodes. In this section, clicking on an active area will link the user to a still photo or document so the user can view the item and return to the application. The text is red in the on-line version. In these samples, we have changed the font to indicate jump points. Using a high quality graphic or photo is extremely beneficial to the user in this section because there is no description of these items in the maintenance card. Pictures clarify the material and help the user to understand and remember exactly what each item is.

> ...visuals can be beneficial when they provide an initial organizational aid or aid in forming a schema or a mental model of how things work that might otherwise have to be constructed by the learner from the text. (Wetzel et al., 1993, p. 47)

3. Exit/Quit

The user was always given the option of returning to the main menu where they could then review a different section or exit to program entirely.

4. Feedback

At the end of each subsection the user was asked a series of five questions based on the learning objectives for that subsection. The user was required to answer all of the questions before they were allowed to continue with the lesson. Incorrect responses were automatically linked back to the appropriate portion of the lesson in order to explain what the correct response should have been.

V. DESIGN TOOLS

While there are many multi-media computers on the market, virtually any computer can be outfitted with the requisite accessories to function as a multimedia computer. The system design of our model was based on a Desktop SPARCstation10 running the UNIX operating system and using a Parallax Xvideo card. External peripheral devices include: a SpeakerBox equipped with an in-line attenuator box, a Sony LDP-1550 Videodisc Player and a SUN CD-Rom Player. Future plans included the use of a compact disc drive and a Video Cassette Recorder. Software used included: UNIX Operating System running with Open Windows, MAEstro Authoring Tool and FrameMaker.

A. SYSTEM HARDWARE

1. SUN Desktop SPARCstation10

The SPARCstation10 is a high performance workstation designed to be used alone or as part of a network (Sun Microsystems, 1992).

2. Parallax Xvideo Card

The Parallax Xvideo Card integrates photographic imaging, hardware image compression, and realtime 24-bit video digitizing. Xvideo makes it possible to squeeze, clip and place live video in any location on the screen. Motion video can be either stored and played back from a hard disk or shared over a network. Other capabilities include:

- Realtime frame capturing from a live video input
- Simultaneous video inputs
- Live video output from a window
- Fully integrated JPEG image compression
- Digital Video. The JPEG compression facilities in Xvideo allow designers to recording of motion video clips and play it back from UNIX files stored on the hard disk. Note: Compressed video is memory intensive. One minute of compressed video can require 12 MBytes of memory.
- 24-bit Video Plus Flexible Overlays. (Parallax Graphics, Inc., 1991)

3. SpeakerBox with Attenuating Adapter and SunMicrophone

The SpeakerBox provides 16-bit audio quality and input/output functions to the SPARCstation 10. The SpeakerBox can be connected directly to the Attachment Unit Interface(AUI)/Audio port or through an AUI/Audio adapter cable (Sun Microsystems, Inc., 1992). However, the system does not currently support line in/out audio (Finch 1993). Because the line input jack on the speaker box did not work, audio inputs from peripheral devices were connect through the microphone jack. Thus, we had to develop an in-line attenuator that would reduce the audio input from 1 volt peak to peak to less than 500 mV. The black box matched impedance differences between the audio input devices and the microphone jack of the SPARC 10 SpeakerBox. The attenuator was designed to support three individual input devices i.e., Videodisc Player, CD-ROM, and VCR.

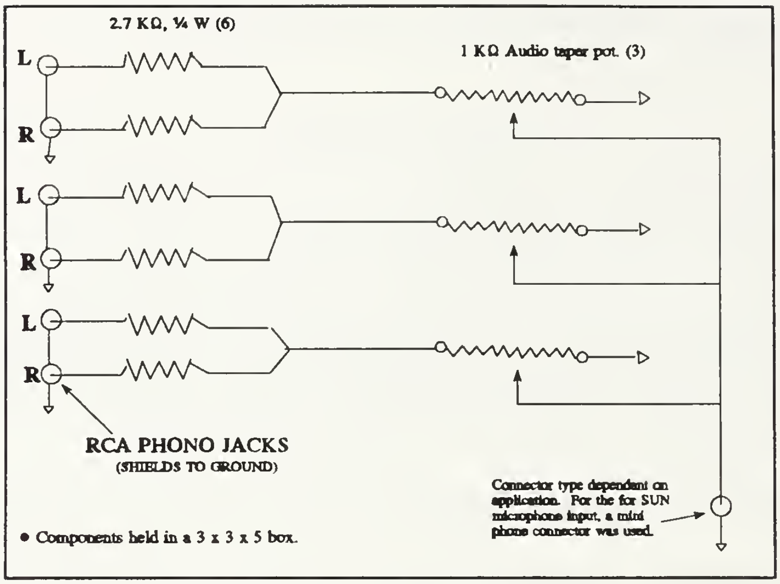

Figure 12. Schematic of in-line attenuating adapter.

The microphone is omni-directional and has a frequency response of 50 Hz to 8 KHz 3dB minimum. The output level is -29dB to 4 Db (Sun Microsystems, Inc., 1992).

4. Sony LDP-1550 Videodisc Player

The Sony LDP-1550 Videodisc Player uses a laser beam as the signal pick-up for contact-free playback of the discs. The player can be controlled by using the control buttons on the player or through a microcomputer. It will run both the constant angular velocity (CAV) discs and constant linear velocity (CLV) discs. **A CAV disc must be used if fast forward or reverse playback is required.**

5. CD-ROM Player

The system will support a computer controllable CD-ROM Player.

B. SYSTEM SOFTWARE

1. UNIX Operating System/OPENWINDOWS

The UNIX Operating System is a multiuser operating system developed by AT&T Bell Laboratories. OpenWindows is a software program using windows and menus with common graphic symbols vice text commands. The software can be used to design custom screens that could be incorporated into an application (Sun Microsystems, Inc., 1990).

2. MAEstro Authoring System

The MAEstro Systems enables integration of multiple media sources into one document. MAEstro was developed as a research project conducted at Stanford University with the assistance of Sun Microsystems and was designed to accommodate various authorship styles and applications. MAEstro was designed with the intention of allowing students and faculty to quickly and easily design and implement multimedia presentations (Drapeau & Greenfield, 1992). MAEstro is a timeline based system, i.e., it is used to launch text, video, and audio segments. This mode of operation creates a linear product that runs until the time line is completed. Thus, MAEstro does not support interactive hypermedia designs.

3. FrameMaker

FrameMaker is a multiplatform document publishing software. It includes many features that are valuable tools in creating interactive, multimedia educational documents. FrameMaker can incorporate information created in

several different applications. For example, Maker Interchange Format (MIF), Sun rasterfile, TIFF, ASCII, and xwd files can be imported into a FrameMaker document (Frame Technology Corporation, 1990).

In addition to being able to incorporate documents from different applications, FrameMaker has a multiplatform capability that allows you to share documents across different computers. This makes it possible to create a document on a PC under windows and run it on a SUN Workstation such as the Sun SPARCstation 10.

In FrameMaker you can create hypertext documents for others to read on the screen. This was the feature that allowed us to develop an on-line, interactive, educational model incorporating multimedia. The hypertext document has active areas in which the reader can clink and go to another page or document, display an alert box, connect to a multimedia presentation, or close a window. Moving around the document in a nonlinear manner is called "jumping" through the document. FrameMaker has the capability of keeping track of the last twenty four jumps. This allows the reader to click and trace their last twenty four jumps. The procedure of creating active areas, text or graphics, and linking between different sections of the document or different documents while somewhat complicated, is not difficult. Once the hypertext document has been created, it can be saved in a "view only" format. This locks the document in order to prevent readers from having the capability to make changes. Hypertext commands also work in the locked mode.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The design on multimedia courseware should be based upon a foundation of instructional design theory, human factors, and cognitive learning theories. If these elements are not included in a deliberate manner, the interactive learning system will lack some instructional effectiveness. Multimedia's has the ability to gain, hold and direct user attention, but its undisciplined use can easily distract the user. Ad-hoc designs of multimedia courseware do not fully exploit the instructional value of multimedia courseware.

Once information has entered long-term memory it is said to have been learned. Information in long-term memory is organized as a set of relationships, concepts and patterns. Interactive learning systems should be designed with consideration for the flow of information in memory and the organization of knowledge. Practice, drill and rehearsal aid in the transition of new information from short-term memory through working memory and ultimately to long-term memory. Interactive learning systems should include facilities for practice and evaluating performance of basic subskills as well as higher skills by learners.

A notional ILS should attempt to form "cognitive" or simulated apprenticeships where possible. The use of video segments can provide the learner access to a larger body of experts than are normally available in a classroom setting. The

degree of similarity to a real apprenticeship would be determined by the quality of the simulation or practice facilities. The designer must have the appropriate level of interactivity and feedback built into the system for an apprenticeship model to work.

Thorough analysis of the users or target group and task analysis are an essential part of the design process. After identifying who and what is to be taught, the designer must arrange the material in a sequence that best supports learning. Course material and learning objectives should be presented in a sequence that moves from the presentation of general to more specific material.

The use of various instructional techniques such as forced pauses, user control of pace, spaced practice and review can enhance learning.

Our research indicates that the most effective design paradigm for an interactive learning system combines user (internal) control, hypermedia, and surrogation.

Finally the presentation of the screen displays is a vital component of the textual matter within the course. Information should "jump off" the screen. The user should not have to search for relevant information or instructions. The designer who produces displays that are readily organized reduces the possibility that the learner will organize the material differently and perhaps erroneously.

B. RECOMMENDATIONS

The design of any follow-on multimedia courseware should be completed in an open systems architecture. There are numerous UNIX and MS-DOS based authoring tools available that facilitate the development of interactive hypermedia documents that can be used as multimedia courseware. The Portable Software Project (PORTCO) under development at the Naval Personnel Research and Development Center (NPRDC) should be explored (National Institute of Standards and Technology, 1990).

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APPENDIX A (MAINTENANCE TASK)

PROCEDURE

NOTE 1: Perform this MRC to determine mount readiness for firing. The PHM-1 Class ships shall perform this MRC in port prior to getting underway for a firing exercise, except for step 1.f. which shall be performed when underway just prior to firing exercise.

Preliminary

a. Perform MRC R-6 prior to performing this MRC.

b. Ensure gun is in battery.

c. Ensure muzzle cap and forward ejector chute covers are removed.

1. Perform Pre-firing Inspections.

NOTE 2: An officer shall witness the inspection of recoil/counterrecoil system fluid level.

a. Inspect recoil/counterrecoil system fluid level (fig 1):

(1) Verify gage rod indicator is between the maximum and minimum indicator marks on gage tube.

(2) If fluid level is incorrect, refer to MRC U-2 and perform steps 1.b.(1) through 1.b.(12) to fill or drain.

NOTE 3: An officer shall witness the inspection of recoil/counterrecoil system pressure.

NOTE 4: Recoil/counterrecoil system fluid level must be correct prior to inspecting recoil/counterrecoil system pressure.

b. Inspect recoil/counterrecoil system pressure (fig 1):

(1) Ensure valve B is closed using nitrogen valve adapter.

(2) Slowly open valve A using nitrogen valve adapter.

(3) Pressure gauge should indicate 70 to 74 kg/cm^2. If pressure is incorrect, refer to MRC U-2 and perform steps 2.b(1) through 2.b.(14) to replenish.

(4) Close valve A using nitrogen valve adapter.

(5) Open valve B using nitrogen valve adapter to bleed pressure from gage. Close valve B.

c. Inspect rocking arm and starwheels.

(1) Verify integrity of nose clamp bushings on both rocking arms. If bushings are loose or have fallen out, replace nose clamp.

(2) Verify upper and lower starwheels are resting against stop levers before proceeding.

d. Inspect safety plunger and safety plunger lever:

(1) Verify safety plunger bushing is lockwired (fig 2).

(2) Using feeler gage stock, verify 1.0mm minimum clearance between safety plunger lever and safety plunger bushing.

(3) Measure safety plunger bushing:

(a) Using steel rule, measure from top surface of safety plunger bushing to top of surface of breechblock (fig 2).

(b) Verify this dimension does not exceed 17mm.

(c) Inspect and replace defective components involved, if safety plunger bushing exceeds this dimension.

(d) Verify integrity of safety plunger lever and trigger springs. Replace if broken or if springs fail to return components to locked position.

e. Test firing pin assembly and firing circuits:

(1) Disengage train and elevation securing mechanisms.

(2) Place gun ant hooks position:

(a) Set circuit breakers CB1 and CB2 to 1 (on).

(b) Press HYDRAULIC UNIT ON pushbutton.

(c) Set cold recoil jacks control valve to RECOILED to move recoiling mass to maximum recoil position.

(d) Set cold recoil jacks control valve to RUN-OUT to allow cold recoil jacks to fully retract and allow recoiling mass to return to hooks position.

(e) Press HYDRAULIC UNIT OFF pushbutton.

WARNING: Injury to personnel or damage to equipment may result if accumulator pressure is not dumped to tank. Allow accumulator to finish dumping on its own before proceeding.

(3) Allow the accumulator to completely dump on its own. Dump any residual pressure by pressing any holding REVOLVING MAGAZINE pushbutton or holding cold recoil jacks handle to the RECOILED position until pressure has been completely dumped.

(4) Insert wax into primer slot of 2 rammable dummy rounds.

(5) Load 2 rammable dummy rounds into outer row of revolving feed magazine.

(6) Press HYDRAULIC UNIT ON pushbutton to start hydraulic power unit.

WARNING: Ensure personnel are clear of gun loading equipment before and while operating gun loading equipment.

(7) Press REVOLVING MAGAZINE pushbutton and verify operation of magazine and screw feeder:

(a) Dummy rounds move smoothly from outer circle to inner circle of revolving magazine.

(b) Dummy rounds move smoothly from inner circle of magazine to last stations of screw feeder.

(8) Release REVOLVING MAGAZINE pushbutton.

(9) Press MOUNT LOADING pushbutton and verify operation of rocking arms and loader drum:

(10) Release MOUNT LOADING pushbutton.

(11) Using screwdrivers, release empty case consent.

WARNING: Stand clear of rocking arms and gun barrel when indexing 2HP1 to ram a round.

NOTE 5: If fast ram interlock is not installed, omit steps 1.e.(12), 1.e.(14), 1.e.(15), and 1.e.(19).

(12) Actuate the Fast Ram Interlock Bypass switch. Verify the fast ram interlock can be withdrawn and remade at the hooks position and the empty case consent mode.

(13) Use T-handle assembly in 2HP1 to manually cycle rocking arms once to ram dummy round (if fast arm interlock is not installed).

(14) Verify the round indexed onto tray and fast arm interlock is holding the gun (out of battery) at hooks position.

(15) Actuate the fast ram interlock switch 2S5. Interlock should release gun into battery and ram the round.

(16) Verify ROUND IN BARREL lamp is lit and MISFIRE lamp is not lit.

(17) Press HYDRAULIC UNIT OFF pushbutton.

WARNING: Injury to personnel or damage to equipment may result if accumulator pressure is not dumped into tank. Allow accumulator to finish dumping on its own before proceeding.

(18) Allow the accumulator to completely dump on its own. Dump any residual pressure by pressing and holding REVOLVING MAGAZINE pushbutton or holding cold recoil jacks handle to the RECOILED position until pressure has been completely dumped.

(19) Verify the fast ram interlock solenoid (3HY2) de-energizes and the linkage extends to the non-ramming position.

(20) Set circuit breakers CB1 and CB2 to 0 (off).

(21) Pull to rear and hold handle of counter rebounding mechanism.

(22) Use breech manual handwheel to eject rammable round and latch open breech.

(23) Remove dummy round from breech and verify no firing pin indentation in primer wax.

(24) Remove and stow handwheel.

(25) Set circuit breakers CB1 and CB2 to 1 (on).

(26) Press HYDRAULIC UNIT ON pushbutton.

(27) Set cold recoil jacks control valve to RECOILED to move recoiling mass to maximum recoil position.

(28) Set cold recoil jacks control valve to RUN-OUT to allow cold recoil jacks to fully retract and allow recoiling mast to return to hooks position.

(29) Using screwdrivers, release empty case consent.

WARNING: Stand clear of rocking arms and gun barrel when indexing 2HP1 to ram a round.

(30) Use T-handle assembly in 2HP1 to manually cycle rocking arms once to ram a round (if fast ram interlock is not installed).

NOTE 6: If fast ram interlock is not installed, omit steps 1.e.(31, 1.e.(32), and 1.e.(34).

(31) Verify the round indexed onto tray and fast ram interlock is holding the gun (out of battery) at hooks position.

(32) Actuate the fast ram interlock switch 2S5. Interlock should release gun into battery and ram the round.

(33) Press HYDRAULIC UNIT OFF pushbutton.

(34) Verify fast ram interlock solenoid (3HY2) de-energizes and linkage extends to non-ramming position.

(35) Position circuit breakers CB1 and CB2 to 0 (off).

(36) Clear training circle of personnel and equipment. Fold down lifelines/other ship equipment necessary to provide clear training and firing zone.

WARNING: Establish communication with safety observer and ensure area is clear before training and elevating gun.

(37) Establish communications with fire control.

WARNING: Train runaway can occur with gun in remote.

(38) Position circuit breakers CB1 and CB2 to 1 (on).

(39) Set LOCAL/REMOTE switch to REMOTE. Verify GUN IN REMOTE green indicating lamp is lit.

(40) Request from CIC a gun train and elevation order to a known nonfiring zone.

(41) Request firing circuit to be energized in CIC. Close firing key in CIC.

(42) Request a train order from nonfiring zone to firing zone. Verify firing pin does not release until gun barrel clears nonfiring zone.

(43) Verify MISFIRE indicating lamp is lit.

(44) Open firing key in CIC.

(45) Request CIC secure gun order signals and firing circuit.

NOTE 7: An officer shall witness that the firing cutout solenoid has retracted to the non-firing position (solenoid de-energized) after the firing key is opened.

(46) Set LOCAL/REMOTE switch to LOCAL. Verify GUN IN REMOTE green indicating lamp is not lit.

(47) Use TRAINING and ELEVATION switches to train gun mount to normal stow position (may require re-energization of train and elevation power drives).

(48) Press ELEVATION-OFF and TRAINING OFF pushbuttons.

(49) Set circuit breakers CB1 and CB2 to 0 (off).

(50) Pull to rear and hold handle of counter-rebounding mechanism.

(51) Use breech manual handwheel to latch open breech.

(52) Remove rammable dummy round from breech and verify firing pin protrusion by observing indentation in primer wax.

(53) Remove and stow handwheel.

NOTE 8: Refer to latest NSWC list of effective drawings/certification sheets for last revision of Gun Pointing and Firing Zone Data Drawings.

NOTE 9: Weapons Officer shall verify results of this maintenance requirement against previously recorded entries in combat systems smooth log to ensure firing cutout zones have not degraded.

NOTE 10: Report any out of tolerance readings to nearest NAVSEACEN representative.

WARNING: After any alteration to ship superstructure, Gun Pointing and Firing Zone Data Drawings must be recertified and approved by a NAVSEACEN representative.

NOTE 11: Any adjustment to the firing cutouts by ships force will be performed only in an EMERGENCY determined by the Commanding Officer.

(54) Position circuit breakers CB1 to 1 (on).

(55) Set LOCAL/REMOTE switch to LOCAL. Verify GUN IN LOCAL red indicating lamp is lit.

(56) Start train and elevation motors.

(57) Position the gun close to a known NON-FIRING ZONE using train switch S-3 and elevation switch S-6.

(58) Deenergize train and elevation motors.

(59) Train (elevate gun with handcrank into the NON-FIRING ZONE until the FIRING CUTOUT indicator lamp is lit.

(60) Record train (elevation) position at the synchro box when FIRING CUTOUT indicator lamp is lit.

(61) Repeat steps 1.e(56) through 1.e(60) as necessary to test each nonfiring zone.

(62) Compare readings to the latest NSWC Gun Pointing and Firing Zone Data Drawings.

NOTE 12: An officer shall witness the inspection of chamber and pass of bore plug gage.

f. Inspect bore and chamber:

(1) Manually depress gun to accessible position.

(2) Inspect bore and chamber for flaws.

(3) Pass bore plug gage; if bore plug gage will not pass, inform maintenance group supervisor.

(4) Manually elevate gun to stow position.

g. Test barrel cooling system:

(1) Set circuit breaker CB1 to 1 (on).

(2) Ensure barrel cooling flexible hose is connected to saltwater line quick-connect coupling at barrel cooling panel.

(3) Open saltwater manual shutoff valve at barrel cooling control panel. Verify saltwater pressure gauge indicates approximately 7 kg/cm^2.

(4) Press BARREL COOLING-ON pushbutton; BARREL COOLING-ON green indicating lamp should be lit.

(5) Verify barrel cooling system is operating.

(6) Press BARREL COOLING-OFF pushbutton. Verify barrel cooling system stops, BARREL COOLING-OFF red indicating lamp it lit, and BARREL COOLING-ON green indicating lamp is not lit.

WARNING: To prevent unintentional ramming, do not make empty case consent until instructed by firing procedure. Refer to SM314-AO-MNM-010/GM Mk 75 Mods 0 and 1, table 2-7.

NOTE 13: If actual firing is not conducted, flush barrel cooling system with fresh water.

h. Flush barrel cooling system with fresh water:

(1) Elevate gun to maximum elevation:

(a) Set circuit breaker CB1 to 1 (on).

(b) Press ELEVATION ON pushbutton.

WARNING: Establish communication with safety observer and ensure area is clear before moving gun in elevation.

(c) Use ELEVATION SWITCH to elevate gun barrel to maximum elevation.

(d) Press ELEVATION-OFF pushbutton.

(e) Set circuit breaker CB1 to 0 (off).

(f) Lock safety lock; remove and retain key.

(g) Engage elevation securing mechanism.

(2) Close saltwater manual shutoff valve.

(3) Connect barrel cooling flexible hose to freshwater quick-connect coupling (if applicable).

NOTE 14: For ships without ORDALT 15191 installed, omit steps 1.h(4), 1.h(5), and 1.h(7).

(4) Set CB1 to 1 (on).

(5) Press BARREL COOLING-ON pushbutton.

(6) Open freshwater manual shutoff valve, flush barrel cooling system approximately 5 minutes. Close freshwater manual shutoff valve.

(7) Press BARREL COOLING-OFF pushbutton.

(8) Depress gun to -5 degrees to drain gun barrel components:

(a) Disengage elevation securing mechanism.

(b) Unlock safety lock; set circuit breaker CB1 to 1 (on).

(c) Press ELEVATION-ON pushbutton.

WARNING: Establish communication with safety observer and ensure area is clear before moving gun in elevation.

(d) Use ELEVATION SWITCH to depress gun barrel to -5 degrees.

(e) Use ELEVATION SWITCH to return gun to stow position.

(f) Press ELEVATION-OFF pushbutton.

(g) Set circuit breaker CB1 to 0 (off).

(h) Lock safety lock; remove and retain key.

(i) Engage elevation securing mechanism.

(j) Return equipment to readiness condition.

APPENDIX B (DESIGN GUIDELINES)

Our review of studies and literature, which reflect upon the effectiveness of different modes of presentations on learning and retention, yielded a number of tentative guidelines that can be used. These are listed below, and are intended mainly as an aid to authors of multimedia courseware or interactive learning systems.

(Fleming 1987, pp. 233-260)

1. Attention is highly selective. We can give attention to only a small part of the environment at one time.

2. Attention is drawn to what is novel or different. By manipulating instructional displays the designer can readily introduce novelty.

3. Attention is drawn to moderate complexity.

4. Lean displays focus attention. Include only the most relevant information.

5. Learned cues can direct attention. Example are arrows, underlining, circles, or rectangles around items. Another very effective cue is simply to direct the learner verbally to look for or listen to certain features. Captions can have a strong effect on the amount and kind of attention given pictures. Pictures without attention-directing prompts may be superficially and processed at a very shallow level.

6. Perception is organized. Learners try to construct meaningful wholes from their environment: objects, events, ideas. Unorganized stimulation is difficult to understand and remember. The designer who produces displays that are readily organized reduces the possibility that the learner will organize the material differently and perhaps erroneously.

7. Vision is most sensitive to colors in the middle of the spectrum, yellow and yellow-green, and least sensitive to those at the ends of the spectrum, violet/blue and red.

8. Audiation is most sensitive to middle pitches and falls of towards the lower and higher pitches.

9. Displays and display elements that appear similar tend to be grouped in perception and associated in memory. (similar size, shape, color, function, etc.)

10. Display or elements that appear close together in space or time tend to be grouped in perception and memory.

11. Concreteness in displays facilitates learning.

12. The amount of displayed information that can be processed at one time is quite limited.

14. Learners prefer color. Especially when it has relevance and meaning ("red bird" may be associated with cardinal). Color can direct attention. (ex. Highlighted word or section of a map)

15. Learning is highly dependant on prior knowledge.

16. Repetition increases learning.

17. Repetition with variety is superior to verbatim repetition.

18. Feedback to learners after they have responded facilitates learning.

19. Feedback for incorrect responses should include corrective procedures and further testing and feedback as necessary.

20. Immediate feedback is not always essential or even desirable.

(Chabay & Sherwood 1992, pp. 151-186)

1. Leave lots of blank space. It prevents displays from getting crowed and makes important material standout. **Simpler is better.**

2. Don't use paragraphs. Set off words and phrases using bulletized lists.

3. Mix text and pictures. Labels and captions clarify pictures and graphs.

4. Clarity reduces misunderstanding and confusion. The extra time used to find concise wording is well spent.

5. Highlighting draws focus on salient points (italics, blinking, inverse video, color, etc.)

6. Remove text and graphics from the screen when they are no longer needed. (Helps to focus user attention and reduces interference.)

7. Highlight sparingly. If everything is highlighted then nothing is important.

8. Build up displays incrementally. Don't flood the screen with all the information at once.

9. Break up long texts.

10. Connect text with graphics. Graphics can shorten lengthy textual explanations.

11. Where possible provide a consistent location for displaying new information (a particular region of the screen).

12. Place new items adjacent to logically related items. (takes precedence over consistent display location theory)

13. Make important display items BIG.

14. Avoid making the user type or shift between the mouse and typing.

15. Don't used timed pauses. Printing something to the screen and then delaying for a fixed period before the next output. **Note**: Timed pauses are not the same as a forced pauses used facilitate cognitive processing.

16. Provide instructions. Put instructions on the screen.

17. Provide a menu option to let the user get to the table of contents at any time. It is also beneficial to have a mechanism that clearly marks the sections the user has completed in the table of contents or main menu.

18. Remove inactive control options.

19. Always provide a way out.

20. Provide the user with a sense of where they are in the lesson. (ex. "5 screens to go")

(Wetzel et al., 1993, p. 50)

1. Learning from text will be aided by relevant illustrations.

2. Learning from text that students are required to read is not facilitated by unrelated illustrations.

3. Learning from illustrated portions of a text will have little or no effect on learning from portions of the same text that are not illustrated.

4. Illustrations may function best in aiding long-term retention.

5. Illustrations may function as substitutes for words.

6. Textual prompting or references to pictured information may aid the reader in extracting relevant information from complex illustrations.

7. Readers prefer illustrated text over nonillustrated text even when they do not extract information from the illustrations.

8. Poor readers may benefit more than good readers from illustrations that are not too complex.

(Hapeshi & Jones, 1992, pp. 96-97)

1. Short lists are best presented in auditory form, longer ones in visual form.

2. Where detailed prose is to be presented, it should be in the form of text that can be reviewed. Short summaries of this can be presented in auditory form.

3. Speech information should be used sparingly; expert summaries are better for learning than long passages if the auditory channel is used.

4. Simultaneous speech and visual presentation should be avoided, if the visual event or display must itself be interpreted in verbal form (verbal recoding).

5. If a number of lists or facts are to be learned in a session, alternating mode of presentation reduces forgetting due to interference.

6. Sounds (music and special effects) not relevant to the instructional theme can be distracting and should be avoided.

7. Use speech input to encourage vocalizing of material to be learned; this will enhance recall.

8. Where possible, keep the visual and auditory messages independent; do not assume these will always be presented together.

76mm/62 Cal Gun Mount
Pre-firing Inspections PMS Check R-1

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MAIN MENU

(Select One)

1. Firing Zone Cutout
2. Equilabrator
3. Gun Cooling
4. Safety Precautions
5. Materials & Tools
6. Exit

Perform Prefiring Inspection

SAFETY PRECAUTIONS

1. Forces Afloat comply with NAVOSH Program Manual for Forces Afloat, OPNAVINST 5100.19 series.

2. Observe safety precautions contained in SW314-AO-MMM-010 through 040/GM Mk75 Mods 0 and 1

3. Injury to personnel or damage to equipment may result if accumulator pressure is not dumped to tank.

4. Ensure personnel are clear of gun loading equipment before and while operating gun loading equipment.

5. Stand clear of rocking arms and gun barrel when indexing 2HP1 to ram a round.

Continue

SAFETY PRECAUTIONS

6. Establish communication with safety observer and ensure area is clear before training or elevating gun.

7. Train runaway can occur with gun in remote.

8. After any alteration to ship superstructure, Gun Pointing and Firing Zone Data Drawings must be recertified and approved by a NAVSEACEN representative.

9. To prevent unintentional ramming, do not make empty case consent until instructed by firing procedure. Refer to SW314-AO-MMM-010/ GM Mk 75 Mods 0 and 1, table 2-7

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TOOLS, PARTS, MATERIALS,

TEST EQUIPMENT

Materials:

1. (1102) Rags, wiping

2. (3472) Wax, paraffin, technical, VV-W-95 , Hazardous Material, Group 1.

Tools:

1. (0854) ***Gage, bore plug***, fleet, 76MM

2. (0917) ***Wrench, open end***, 8MM, 10MM

3. (0919) Rule, steel, machinist's 6", 1MM graduations

Continue

TOOLS (Continued):

4. (1200) Screwdriver, flat tip, 9" heavy duty (2)

5. (3779) Gage, thickness, Metric, 3" blade length, 0.05 mm to 1.0mm

MISCELLANEOUS:

1. (0920) ***Dummy cartridge***, 76 millimeter, 62 Caliber (2)

2. (2000) ***MRC(s) R-6*** and ***U-2***

3. (3484) ***Fork, breechblock***

4. ***Adapter, nitrogen valve*** 5520553

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Ship System	Subsystem	MRC Code	
Guns & Ammunition	Guns & Mounts	7111 R-1	
System	**Equipment**	**Rates**	**M/H**
Guns 711	Mk 75 Mod 0, 1, 76mm/ 62 Cal Gun Mount 71112V	Weps Off GMG3 2GMGSN	 1.0 2.0
Maintenance Requirement Descriptiion		**Total M/H**	
Perform Pre-firing Inspection		3.0	
		Elapsed Time	
		1.0	

Select one of the following Subsections:

1. **Safety Subsection**

2. **Communication Subsection**

3. **Gun Preparation Subsection**

SAFETY SUBSECTION

(Learning Objectives)

(Examples Only)

1. Be Familiar with safety precautions contained in SW314-AO-MMM-010 through 40.

2. Know who must authorize a tagout.

3. Know who must be notified before check is begun.

4. Know why accumulator pressure must be dumped prior to beginning check.

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SAFETY SUBSECTION

(Procedure)

36) Clear training circle of personnel and equipment. Fold down lifelines/other ship equipment necessary to provide clear training and firing zone.

WARNING: Establish communication with safety observer and ensure area is clear before training or elevating gun.

37) Establish communications with fire control.

WARNING: Train runaway can occur with gun in remote.

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SAFETY SUBSECTION

(Questions)

This is the portion of the program where 5 questions will be asked based on the learning objectives.

All questions must be answered before continuing.

Wrong answers will be linked back to the appropriate portion of the document to explain correct answer.

HELP REVIEW Main Menu

38) Position circuit breakers CB1 and CB2 to I (ON).

39) Set LOCAL/Remote switch to REMOTE. Verify GUN IN REMOTE green indicating lamp is lit.

40) Request from CIC a gun train and elevation order to a known nonfiring zone.

41) Request firing circuit be energized in CIC. Close firing key in CIC.

42) Request a train order from nonfiring zone to firing zone. Verify firing pin does not release until gun barrel clears nonfiring zone.

43) Verify MISFIRE indicating lamp is lit.

44) Open firing key in CIC.

45) Request CIC secure gun order signals and firing circuit.

46) Set LOCAL/REMOTE switch to LOCAL. Verify GUN IN REMOTE green indicating lamp is lit.

47) Use TRAIN and ELEVATION switches to train gun mount to normal stow position (may require re-energization of train and elevation power drives).

48) Press ELEVATION OFF and TRAINING-OFF pushbuttons.

49) Set circuit breakers CB1 and CB2 to O (off).

50) Pull to rear and bold handle of counter-rebounding mechanism.

51) Use breech manual handwheel to latch open breech.

52) Remove rammable dummy round from breech and verify firing pin protusion by observing indentation in primer wax.

53) Remove and stow handwheel.

NOTE 8: Refer to latest NSWC list of effective drawings/certification sheets for latest revision of Gun Pointing and Firing Zone Data Drawings.

NOTE 9: Weapons Officer shall verify results of this maintenance requirement against previously recorded entries in combat systems smooth log to ensure firing cutout zones have not degraded.

NOTE 10: Report any out of tolerance readings to nearest NAVSEACEN representative.

WARNING: After any alteration to ship superstructure, Gun Pointing and Firing Zone Data Drawings must be recertified and approved by a NAVSEACEN representative.

NOTE 11: Any adjustment to the firing cutouts by ship's force will be performed only in an EMERGENCY determined by the Commanding Officer.

54) Position circuit breakers CB1 to 1 (ON).

55) Set LOCAL/REMOTE switch to LOCAL. Verify GUN IN LOCAL red indicating lamp is lit.

56) Statrt train and elevation motors.

57) Position the gun close to a known NON-FIRING ZONE using train switch S-3 and elevation switch S-6.

58) De-energize train and elevation motors.

59) Train (elevate) gun with handcranck into the NON-FIRING ZONE until the FIRING CUTOUT ZONE indicator lamp is lit.

60) Record train (elevation) position at the synchro box when FIRING CUTOUT indicator lamp is lit.

61) Repeat steps i/e/ (56) through i/e/ (60) as necessary to test each nonfiring zone.

62) Compare readings to the latest NSWC Gun Pointing andFiring Zone Data Drawings.

WARNING: Establish commmunication with safety observer and ensure area is clear before moving gun in elevation.

1) Use ELEVATION SWITCH to depress gun barrel to -5 degrees.

2) Use ELEVATION SWITCH to return gun to stow position.

3) Press ELEVATION-OFF pushbutton.

4) Set circuit breaker CB1 to O(Off).

5) Lock safety lock; remove and retain key.

6) Engage elevation securing mechanism.

HELP

The following help regarding the question portion of the program is as follows:

1. You must answer every question before proceeding to the next section.

2. To view video pertaining to the learning objectives, select the *Review* button.

OK

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